Novel Fingerprint Scanning Arrays Using Polysilicon TFT's on Glass and Polymer Substrates

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Abstract—**Novel fingerprint scanning arrays based upon capacitance sensing have been made. Each sensor element consists of a capacitor electrode and two poly-Si thin film transistors for addressing and read out. The devices were fabricated on glass, polyimide and polyethersulphone substrates using a low temperature (<250 °C) process.**

I. Introduction

THERE IS considerable interest in poly-Si TFT's on glass substrates for active matrix liquid crystal displays (AMLCD's). The poly-Si devices have good enough characteristics to allow row and column driving circuits to be integrated onto the glass panel [1], [2], and it is expected that the integration of entire systems onto the panel might be achieved ultimately. In addition to displays, other system elements such as EEPROM memories have also been developed [3]. Furthermore, as process temperatures continue to fall, these systems might be manufactured on lightweight, robust, polymer substrates. In the present work, we take further steps toward these goals by demonstrating novel fingerprint scanning arrays on glass and polymer substrates. Such low cost devices may be useful for a wide range of applications including banking, access control, smart cards, and personalization.

II. Poly-Si TFT's

The device structure is shown in Fig. 1. The devices were fabricated on 1.1 mm thick glass substrates, 0.125-mm thick polyimide (PI) substrates, and 0.1–0.5-mm thick polyethersulphone (PES) substrates. Firstly, the polymer substrates were preshrunk at the temperature of thin-film-deposition in order to achieve dimensional stability to better than 3 μm across the plate (85 mm) (i.e., less than 3 μm of further movement expected during the subsequent thermal processing steps). Next, stacks of silicon nitride, silicon dioxide and amorphous silicon were deposited in a multi-chamber PECVD reactor. The depositions were at 250 °C on glass and polyimide, and at 200 °C on polyethersulphone. The TFT source and drain regions were implanted through a resist mask, and the film was crystallized with an excimer laser [4], [5]. Such processing of thin Si films with excimer lasers to produce poly-Si has been reported previously [6], [7]. Following this, the poly-Si was patterned, and 0.15 μm of PECVD oxide was deposited. Then, contact windows were opened, and chromium

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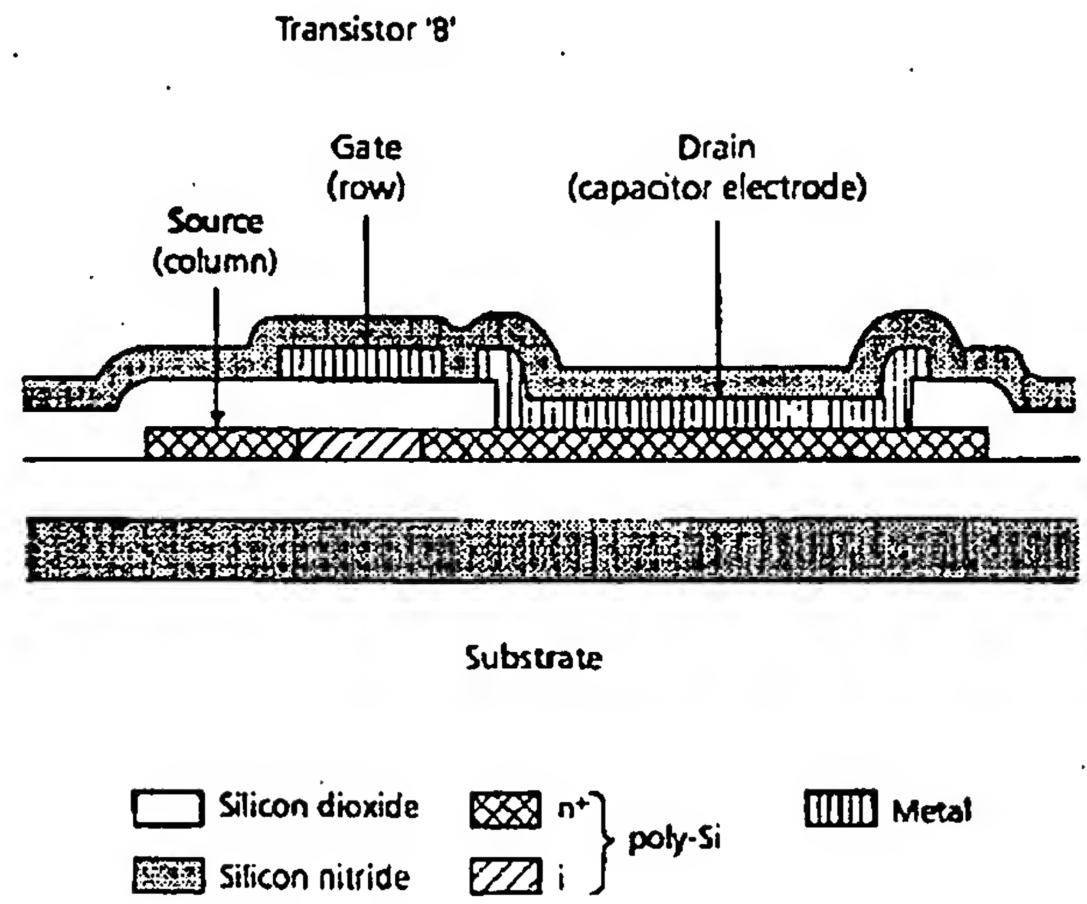

Fig. 1. Cross-section showing the poly-Si TFT device structure, capacitor electrode, and row and column conductors of the fingerprint scanning array.

or aluminum was deposited and patterned to form the gate lines (rows). Next, the 0.1 μm silicon nitride capacitor dielectric was deposited by PECVD, and contact windows through this were opened at the edges of the plate. Finally, the devices were annealed in mixed gas to passivate defects; the glass substrates were annealed at 300 °C for 1 h, the polyimide substrates at 250 °C for 16 h, and the polyethersulphone substrates at 200 °C for 20 h. Typical device transfer characteristics obtained on glass and polyethersulphone are shown in Fig. 2. Those obtained on polyimide typically lie between those on glass and polyethersulphone.

III. Scanner

The fingerprint scanner works on the principle of capacitance sensing. A block of four elements of a 2-D scanning array is shown in Fig. 3(a). Each element consists of a capacitor electrode covered with 0.1 μm of silicon nitride insulator, connected to two poly-Si TFT's. When the ridge of a fingerprint lies directly over the electrode a capacitor is formed between the electrode and the finger, and this is charged through transistor A when a row pulse is applied. The stored charge is then transferred onto a column electrode through transistor B when the following row is pulsed. The charge on the column is then integrated by external circuitry. If a trough in the fingerprint lies over the electrode, then the capacitance is very much smaller, and a negligible charge results.

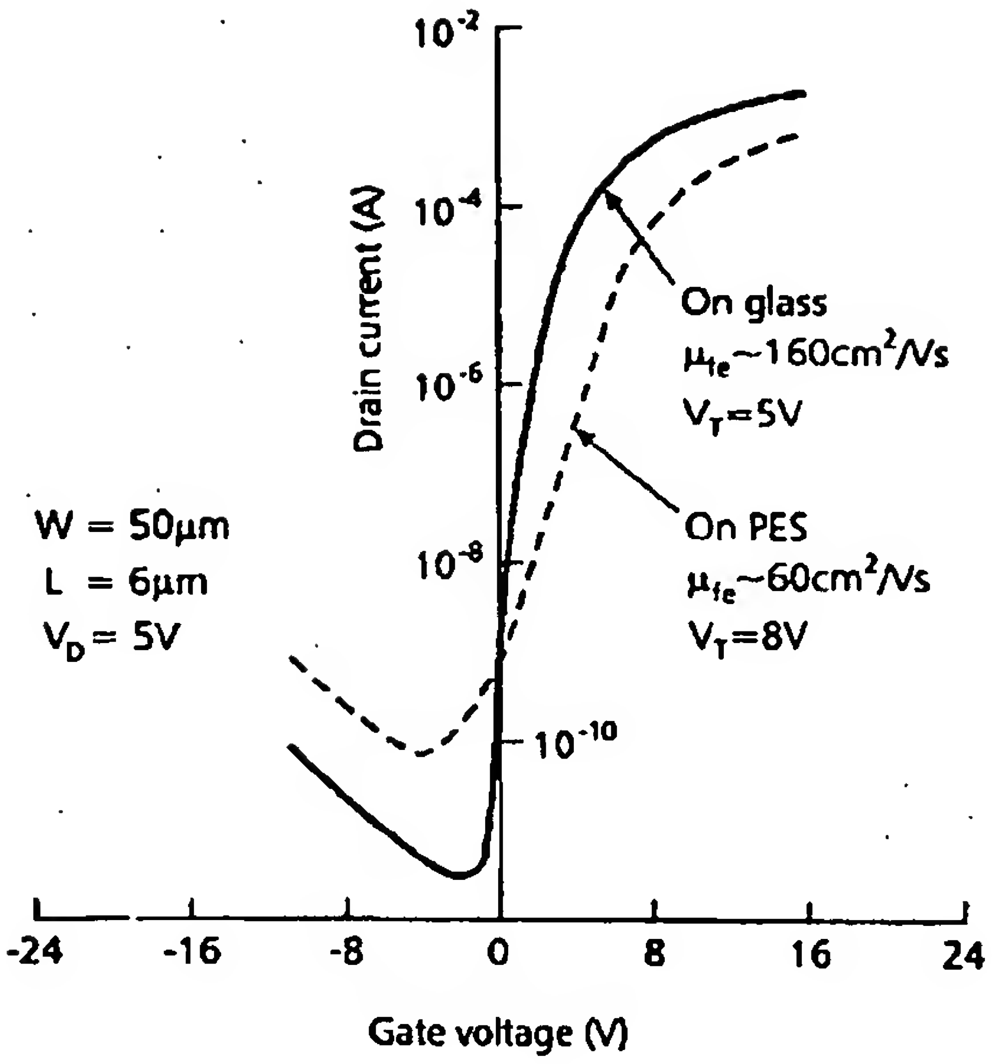

Fig. 2. Typical transfer characteristics of poly-Si TFT's formed on glass and polyethersulphone (PES) substrates.

The present scanners consist of an array of 200 × 200 elements at a pitch of 100 μm, and the row driving and charge integration are performed by external silicon chips. The row pulses are 8–10 V in magnitude, and 10–100 μs in duration. A typical image from a scanner on glass is shown in Fig. 3(b). Scanners on polymer similarly produce images, though defect densities (i.e., line discontinuities, and row to column shorts) are currently high, and this requires further investigation. Fast frame rates (>500 s^{-1}) are possible due to the charging then immediate discharging of each pixel. However, this is limited in practice to ~100 s^{-1} by external mono-Si charge integrators. Designs with a 50-μm pitch and integrated poly-Si row and column circuitry are currently being studied. These will operate at a lower frame rate of ~15 s^{-1}.

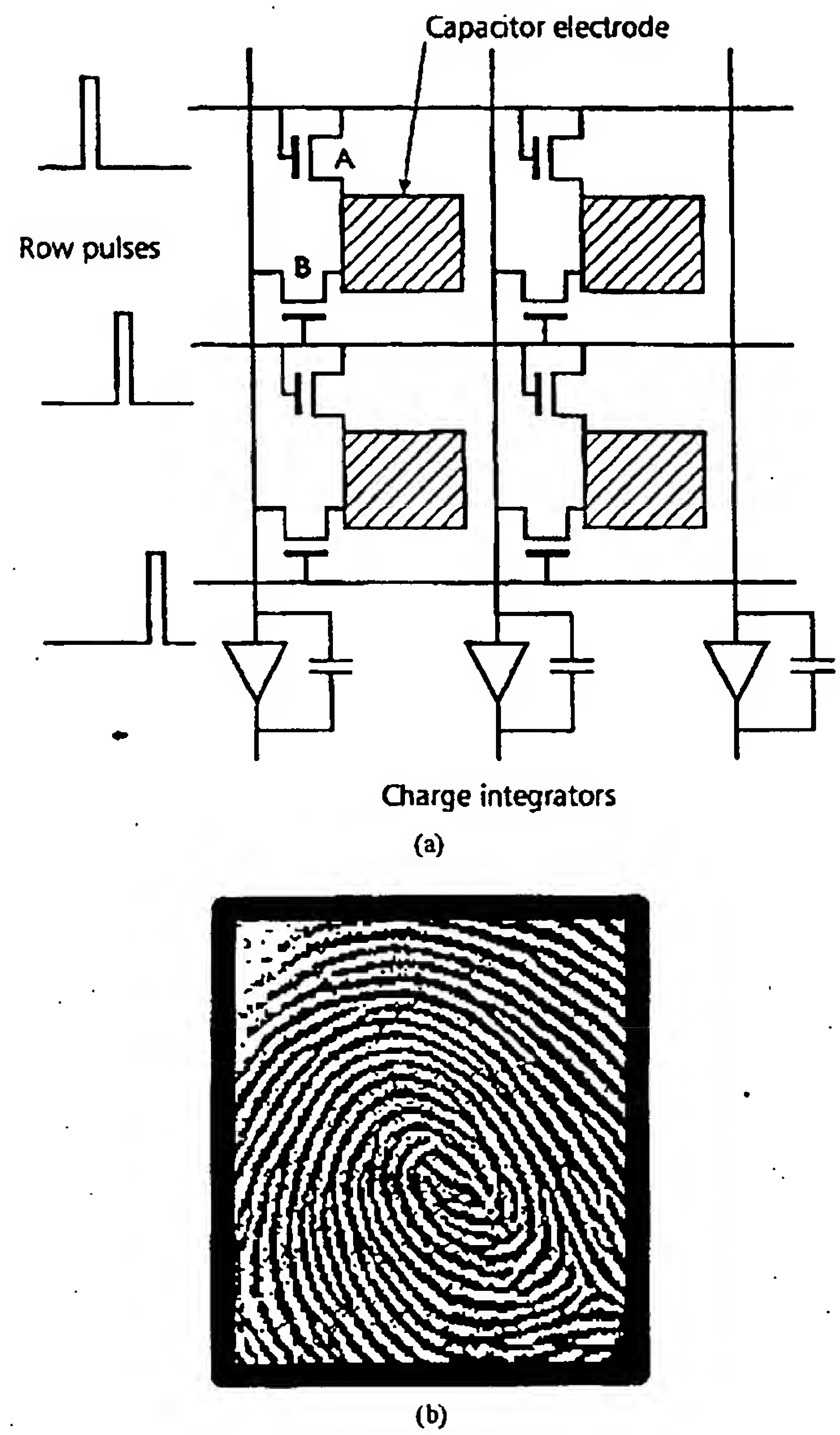

Fig. 3. (a) The capacitance sensing elements of the scanner and (b) a typical image of a fingerprint obtained by a scanner.

IV. Conclusions

A novel fingerprint scanner working on the principle of capacitance sensing has been presented. This has been formed on glass and polymer substrates using a low temperature poly-Si TFT process. This involves the deposition of insulators and amorphous silicon by PECVD, and the subsequent crystallization of the amorphous silicon by excimer laser annealing. This compact, low cost scanner might be incorporated into portable products, or even smart cards. Alternatively, these scanners could be made on less robust, higher cost Mono-Si substrates, but with an integrated chip for fingerprint recognition.

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